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## THE GEYSERS OF CALIFORNIA.

BY G. L. GOODALE, M. D.

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THE Geysers of California are situated in lateral ravines of Pluton River, a tributary of Russian River.

The picturesque journey from San Francisco to the Geysers has been truthfully described by many tourists; hence most of our readers are doubtless familiar with the sail over the bay and through the Tulé marsh, the ride up the White-wine valley, the slow ascent of an outlying crest of the Coast Range, and the perilous drive down into the cañon. It is proposed to embody in this paper some observations based upon studies at the Geysers during the last week in May, 1866.

It is, therefore, necessary to pass over, without remark, the interesting journey thither, and occupy ourselves with a description of the Avernus rather than the *facilis descensus*. The Avernus of the Æneid seems to have been a watering-place of some repute, which was in such immediate proximity to the lower regions, and presented such great attractions on account of being upon the most desirable route thither, that the name came, at

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last, to be applied as much to the sulphurous depths below as to the oak-shaded lake above. Various points of interest in this occidental Avernus have received appellations suggested by the surroundings; and while some other localities on the Pacific coast have been named for public officials, it has not been considered complimentary to attach modern proper names to anything in the vicinity of the Geysers. For this reason the classics have been laid under contribution. The stream into which the main cañon opens is called Pluton River, the gorge is known as the Devil's Cañon, and a sulphurous grotto has been long named for Proserpine.

In gaining a clear idea of the California Geysers, it will be necessary to forget the geysers of Iceland, with their columns of water and capitals of cloud. Upon approaching those upon Pluton River, your first impression is that there has been a great conflagration, and that the fire engines are blowing off steam preparatory to going home. The gorge is lined with masses of smouldering ashes, from which hot steam is being drifted by the wind, and, in some places, you can imagine that the embers are ready to relight. In the bottom of the cañon, turbid and blackened water, from which vapor slowly lifts, is running among the discolored rocks. Here and there, escaping steam hisses, and, in some places, roars like the "exhaust" of an engine.

In other smaller cañons and depressions on an irregular table land, there are like appearances of chemical activity. The rocks in the vicinity are mainly sandstones and silicious slates, which are highly metamorphic. The intermediate varieties are innumerable, all belonging to the Cretaceous Series,\* which is largely represented in

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\* Geology of California, vol. 1, p. 94 et seq.

the northern Coast Range of the State. Two belts of eruptive rock have been observed in this part of the State, one lying thirty miles south, and the other found between the Geysers and Borax Lake, twenty or more miles away. Both are on the line of former volcanic activity, and near both we find many thermal springs.

Besides hot springs, incrustations of sublimed sulphur, pumice, and the light lavas are regarded as traces of volcanic action. These are found in many places in California, and in Nevada. The writer has observed these indications near the summit of the extinct volcano, Shasta. In all cases they point to former igneous activity. Therefore, the steam-springs and the Solfataras may be considered, for all practical purposes, as the poor relations of volcanoes in reduced circumstances. Such are the Geysers.

Upon the 28th of May there had been a slight fall of rain. The morning of the 30th was quite cloudy, the thermometer ranging at eight o'clock from 60° to 62° Fahr. The temperature of the water in Pluton River, immediately above the confluence of the stream from the Devil's Cañon varied from 65° to 70°. At the mouth of the cañon the temperature of the water was 90°, and upon walking up the bank of the stream the different temperatures of 95°, 97°, and 100°, were noticed. A light vapor was rising from the surface of the water.

The first spring where ebullition was observed had a temperature of 135°. There was a free escape of sulphydric acid from the cloudy water, and here the hot, stifling moisture began to make the walk one of discomfort. Upon the right hand several small springs of 190°, all giving off sulphydric acid, were boiling violently, and at the edge of a queer miniature cave on the same side,

there was a furious little cauldron seething at  $200^{\circ}$ . Several of the springs had low forms of cryptogamic vegetation growing upon the walls of the basins, and, in some instances, *confervæ* were observed thriving in water of a temperature of  $145^{\circ}$  Fahr. Seventy or eighty rods from the mouth of the cañon, there is a jet of escaping steam, and a little farther on there is an escape-pipe, nearly ten inches in diameter, through which steam is forced out several feet. Part of the steam condenses at five feet from the orifice, the rest ascends as light vapor, and is borne away by the wind. The greatest degree of temperature observed was  $206^{\circ}$  Fahr., where there was, of course, as in the other cases mentioned, apparent ebullition from escape of gases. In no instance was the temperature of  $500^{\circ}$  noticed, which Mr. Bowles\* speaks of in his entertaining "Across the Continent." Obviously, this is a slip of a flying quill.

Upon the east and west sides of the cañon, at this point, the ground is made up of decomposing rocks of clayey consistence, and of various colors dependent upon metallic oxides; each little locality seeming to be a laboratory for the decomposition of silicates. Wherever the light soil was dry, there was no vegetation whatever; wherever there was a good degree of humidity, *confer-void* growths were scattered. Near springs, a few rods farther east, a species of grass, *Panicum*, was seen growing; and, in one instance, at the water's edge where the panicle was bathed in slowly-rising vapor. This species is abundant near fumaroles, which are little natural blast chimneys, lined with crystalline needles of sublimed sulphur.

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\*"Across the Continent," p. 282. "They are of all degrees of temperature, from one hundred and fifty to five hundred."

This leads next to the subject of incrustations, which for our purpose we may divide into three groups, namely : silicic acid, sulphates, and sulphur. The first comprises the crystals of quartz, which are found upon slates embedded in the soil. They are minute, but very perfect.

The sulphates, such as crystals of ferric and magnesian sulphate, and the alums were not seen in their best estate. The rain of May 28th had dissolved the largest ones, and while we regretted this loss, we consoled ourselves with the thought that the rain, which had robbed us of our jewels, had added intensity to the chemical action going on around and below. It is stated upon good authority that the action is more intense during, or at the close of the rainy season, which is the winter of California.

The sublimed sulphur presents the two prevailing forms; namely, that which has crystallized with free access of air, and resembles the obtuse oblique rhombic prisms of sulphur familiar to chemists; and that which is produced under pressure, and has a slight inclination of the vertical axis.

In some limited localities there are effloresced salts, and pale, faded carbonates. At one spot, a light green cupric carbonate was partially covered with a darker green confervoid growth, and each shaded into the other like colors on a palette.

But the salts just referred to are those which have been left by the heavily charged water. Imagine, therefore, the variety of dissolved salts which must have been formed, by the over-heated steam and sulphur acids, from the rocks which are being so rapidly leached under pressure. The solutions are, almost in every case, acidulated by a high sulphur acid; free sulphur floats in the water, and

sulphydric acid escapes with violent ebullition. It must be supposed that in these acidulated solutions, the iron exists as a ferrous salt, since sulphydric acid has this reducing power.

In one spring, which is very nearly neutral, the iron has been incompletely precipitated and is suspended, in the agitated water, with other insoluble sulphides.

Another spring is strongly acidulated, and contains only the merest trace of the sulphydric acid, which everywhere fills the atmosphere. The rationale of the reactions observed at the Geysers is not obscure, but so far as the writer is aware, no careful analyses of the waters and sinter have been made upon the spot. The scrupulous care with which the geological survey of California is being conducted, warrants the conclusion that trustworthy examinations will be published in due time.

The writer is unwilling to conclude this imperfect sketch of one of the wonders of California, without bearing his personal testimony to the value of the labors of Professors Whitney and Brewer, and the hard-working corps.

The first volume upon geology has been read and questioned in the presence of the Coast Range and Sierra, from Point Concepcion to the Oregon line, and it has, at all times, proved a reliable guide.

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NOTE.— See, also, a very interesting article by Professor F. Shepherd, in "Silliman's Journal" for September, 1851, when the springs were far less easily accessible than now.